This listing of claims will replace all prior versions, and listings, of claims in the application:

Claim 1 (currently amended): An apparatus for generating at least one hybrid arc/microwave plasma discharge, the apparatus comprising:

a) a cavity adapted to support at least one of a TE mode and a TM mode at a microwave frequency; ~~and~~

b) ~~a~~ an arc torch module, coupled with the cavity, for generating seed plasma within the cavity; and

c) a microwave source, coupled with the cavity, for generating microwaves at the microwave frequency, and for introducing the generated microwaves into the cavity,

wherein the arc torch module is capable of generating a plasma torch which exits the cavity in the absence of microwave energy, said generated plasma torch having a first energy level.

Claim 2 (original): The apparatus of claim 1, wherein the cavity is a tapered cavity.

Claim 3 (cancelled)

Claim 4 (currently amended): The apparatus of claim 1, ~~wherein the torch module is an arc torch module, and~~ wherein the seed plasma generated by the arc torch module discharge triggers microwave discharge in the cavity thereby generating additional plasma.

Claim 5 (original): The apparatus of claim 4 wherein an exit opening is defined in the cavity at a location opposite the arc torch module, wherein plasma is generated by a combination of an arc discharge and microwave discharge, and wherein the generated plasma exits the cavity through the exit opening as the hybrid arc/microwave discharge.

Claim 6 (currently amended): An apparatus for generating at least one hybrid arc/microwave plasma discharge, the apparatus comprising:

a) a cavity adapted to support at least one of a TE mode and a TM mode at a microwave frequency ~~The apparatus of claim 1,~~ wherein, said cavity includes a first wall and a second wall opposing the first wall, wherein the torch module is fitted into the first wall of the cavity, and wherein an exit opening is defined in the second wall of the cavity at a location opposed to the location of the torch module; and

b) a torch module, coupled with the cavity, for generating seed plasma within the cavity.

Claim 7 (original): The apparatus of claim 1, wherein said cavity has a narrow section, a wide section, and a tapered section arranged between the narrow and wide sections.

Claim 8 (currently amended): An apparatus for generating at least one hybrid arc/microwave plasma discharge, the apparatus comprising:

a) a cavity adapted to support at least one of a TE mode and a TM mode at a microwave frequency,

wherein said cavity has a narrow section, a wide section, and a tapered section arranged between the narrow and wide sections and ~~The apparatus of claim 7~~ wherein both the narrow section and the wide section have rectangular cross sections; and

b) a torch module, coupled with the cavity, for generating seed plasma within the cavity.

Claim 9 (original): The apparatus of claim 8, wherein the cavity is dimensioned to support a TE_{10n} mode at the microwave source frequency, wherein n is an integer that is at least 3.

Claim 10 (original): The apparatus of claim 6, wherein said cavity includes

- endwalls substantially orthogonal to the first and second wall, and
- additional walls arranged between the endwalls and including the first and second walls,

wherein the hybrid arc/microwave plasma discharge exits the cavity from the exit opening of the second wall.

Claim 11 (withdrawn): The apparatus of claim 1, further comprising at least one additional torch module coupled with the cavity, wherein the seed plasma generated by the arc discharges of the torch modules is energized by a TE mode electric field rather that by a TM mode, the seed plasma triggering subsequent microwave discharges thereby generating at least two hybrid arc/microwave plasma discharges.

Claim 12 (withdrawn): The apparatus of claim 11, wherein, said cavity includes a first wall and a second wall opposing the first wall, wherein the torch modules are fitted into the first wall of the cavity, and wherein exit openings are defined in the second wall of the cavity at a location opposed to the location of the torch modules, wherein said cavity includes endwalls substantially orthogonal to the first and second walls, and wherein the hybrid arc/microwave plasma discharges exit the cavity from the two exit holes of the second wall.

Claim 13 (original): The apparatus of claim 10, wherein said cavity has a narrow section, a wide section, and a tapered section arranged between the narrow and wide sections,

wherein said cavity includes a narrow section defined by the additional walls, the narrow section having a height of about 5 mm, a first of the additional walls having a first opening defined therein at which the torch module is fixed, a second of the additional walls having a second opening defined therein,

wherein the second opening permits the hybrid arc/microwave plasma torch to exit, and

wherein the first and second openings are located at one of the electric field maximum locations of the TE_{10n} mode, and the tapered section including two end locations, the end locations of the taper section located at electric field minimum locations of said TE_{10n} mode.

Claim 14 (currently amended): An apparatus for generating at least one hybrid arc/microwave plasma discharge, the apparatus comprising:

a) a cavity adapted to support at least one of a TE mode and a TM mode at a microwave frequency, wherein said cavity has a narrow section, a wide section, and a tapered section arranged between the narrow and wide sections ~~The apparatus of claim 7~~, and wherein the narrow section has a length of about $m\lambda_z/2$, where λ_z is the wavelength of said TE_{10n} mode in the axial direction of the cavity, and m is an integer determined by the number of torches to be hosted in said cavity; and

b) a torch module, coupled with the cavity, for generating seed plasma within the cavity.

Claim 15 (currently amended): An apparatus for generating at least one hybrid arc/microwave plasma discharge, the apparatus comprising:

a) a cavity adapted to support at least one of a TE mode and a TM mode at a microwave frequency, wherein said cavity has a narrow section, a wide section, and a tapered section arranged between the narrow and wide sections; and

b) a torch module, coupled with the cavity, for generating seed plasma within the cavity ~~The apparatus of claim 7~~, wherein said cavity is a low Q cavity with a value less than 30,

wherein said torch module generates seeding plasma generating additional plasma without requiring microwave breakdown, and

wherein said cavity includes an exit opening to exit the hybrid arc/microwave plasma discharge, said exit opening having a larger diameter than would be possible if

said torch module did not generate seeding plasma, said larger diameter exit opening resulting in a increase in the size of the plasma discharge.

Claim 16 (original): The apparatus of claim 1, wherein said torch module includes a frame, a central electrode, and a ceramic insulator, the frame including an outer electrode which is electrically connected to the cavity, the ceramic insulator insulating the central electrode from the frame of the module and from the cavity.

Claim 17 (original): The apparatus of claim 16, wherein said torch module frame includes openings to couple inlet gas into a gas chamber of said torch module.

Claim 18 (original): The apparatus of claim 1, wherein the hybrid arc/microwave plasma discharge forms a column, said column reaching a height of about 6 cm and a diameter of about 2 cm.

Claims 19 and 20 (cancelled)

Claim 21 (currently amended): An apparatus for generating at least one hybrid arc/microwave plasma discharge, the apparatus comprising:

a) a cavity adapted to support at least one of a TE mode and a TM mode at a microwave frequency;

b) a torch module, coupled with the cavity, for generating seed plasma within the cavity;

c) a microwave source, coupled with the cavity, for generating microwaves at the microwave frequency, and

for introducing the generated microwaves into the cavity;

d) a first power supply module to power the microwave source; and

e) a second power supply module to power the torch module,

wherein the first and second power supply modules share a common transformer ~~The apparatus of claim 20~~, and

wherein primary input power is selected from at least one of a 60Hz, 50Hz, and 400Hz AC primary power source, wherein the time average power of approximately 700W is supplied by said first power supply module, and wherein hybrid arc/microwave discharge has a cycle energy of approximately 12 J/cycle

Claim 22 (currently amended): An apparatus for generating at least one hybrid arc/microwave plasma discharge, the apparatus comprising:

a) a cavity adapted to support at least one of a TE mode and a TM mode at a microwave frequency;

b) a torch module, coupled with the cavity, for generating seed plasma within the cavity;

c) a microwave source, coupled with the cavity, for generating microwaves at the microwave frequency, and for introducing the generated microwaves into the cavity;

d) a first power supply module to power the microwave source; and

e) a second power supply module to power the torch module,

wherein the first and second power supply modules share a common transformer ~~The apparatus of claim 20~~, and

wherein, the first power supply module includes a coupling capacitor of approximately 1 micro-Farad, wherein the second power supply includes a coupling capacitor of 1 micro-Farad and a limiting resistor of approximately 750 ohms, and wherein the common transformer has a turns ratio of approximately 1:25.

Claim 23 (currently amended): An apparatus for generating at least one hybrid arc/microwave plasma discharge, the apparatus comprising:

a) a cavity adapted to support at least one of a TE mode and a TM mode at a microwave frequency ~~The apparatus of claim 3~~, wherein the cavity is dimensioned to support a TE_{10n} mode at the microwave source frequency, where n = 3, wherein the microwave frequency is approximately 2.45 GHz, and wherein the cavity includes a first section, a second section, and a third section, said first section having the dimensions of a S-band WR-284 waveguide of approximately 7.2 cm x 3.4 cm and a length of approximately 8.74 cm, said third section having the dimensions of approximately 7.2 cm x 0.5 cm and a length of approximately 11.65 cm, said second section being a middle section, being tapered, having a width of approximately 7.2 cm, a height ranging from approximately 3.4 cm to approximately 0.5 cm, a length of approximately 11.65 cm and a slope angle of approximately 14 degrees;

b) a torch module, coupled with the cavity, for generating seed plasma within the cavity; and

c) a microwave source, coupled with the cavity, for generating microwaves at the microwave frequency, and for introducing the generated microwaves into the cavity.

Claim 24 (currently amended): An apparatus for supporting generation of at least one hybrid arc/microwave plasma discharge, the apparatus comprising:

a) a cavity supporting at least one of a TE mode and a TM mode at a microwave frequency; ~~and~~

b) means for coupling at least one arc torch module to said cavity; and

c) means for a plasma torch to exit the cavity, wherein said means for coupling at least one arc torch module to said cavity is on a first wall of the cavity, wherein said means for a plasma source to exit the cavity is located on a second wall of the cavity, wherein said first and second walls are different, and wherein said first and second walls are substantially planar.

Claim 25 (original): The apparatus of claim 24, wherein the means for coupling at least one torch module include a threaded portion attached to a wall of said cavity.

Claim 26 (original): The apparatus of claim 24, wherein the dimensions of the cavity support a TE_{10n} mode at the microwave source frequency, where n is an integer of at least 3.

Claim 27 (withdrawn): The apparatus of claim 24, further comprising:

c) means for coupling at least one additional torch module to said cavity, wherein said torch plasma is energized by a TE mode electric field rather that by a TM mode, and wherein at least two hybrid arc/microwave plasma discharges are generated.

Claim 28 (currently amended): An apparatus for supporting generation of at least one hybrid arc/microwave plasma discharge, the apparatus comprising:

a) a cavity supporting at least one of a TE mode and a TM mode at a microwave frequency; and

b) means for coupling at least one torch module to said cavity ~~The apparatus of claim 24~~, wherein, said cavity includes a first wall and a second wall opposing the first wall, wherein the means for coupling is provided on the first wall of the cavity, and wherein an exit opening is defined in the second wall of the cavity at a location opposed to the location of the means for coupling.

Claim 29 (original): The apparatus of claim 24, wherein said cavity has a narrow section, a wide section, and a tapered section arranged between the narrow and wide sections.

Claim 30 (currently amended): An apparatus for supporting generation of at least one hybrid arc/microwave plasma discharge, the apparatus comprising:

a) a cavity supporting at least one of a TE mode and a TM mode at a microwave frequency; and

b) means for coupling at least one torch module to said cavity,

wherein said cavity has a narrow section, a wide section, and a tapered section arranged between the narrow and wide sections, and ~~The apparatus of claim 29~~ wherein both the narrow section and the wide section have rectangular cross sections.

Claim 31 (original): The apparatus of claim 30, wherein the cavity is dimensioned to support a TE_{10n} mode at the microwave source frequency, wherein n is an integer that is at least 3.

Claim 32 (original): The apparatus of claim 28, wherein said cavity includes endwalls substantially orthogonal to the first and second walls, wherein torch plasma forming the hybrid arc/microwave plasma discharge exits the cavity from the exit opening of the second wall.

Claim 33 (original): The apparatus of claim 32, wherein said cavity has a narrow section, a wide section, and a tapered section arranged between the narrow and wide sections,

wherein said cavity includes a narrow section defined by the additional walls, the narrow section having a height of about 5 mm, a first of the additional walls having a first opening defined therein at which the torch module is fixed, a second of the additional walls having a second opening defined therein,

wherein the second opening permits the hybrid arc/microwave plasma discharge to exit, and

wherein the first and second openings are located at one of the electric field maximum locations of the TE_{10n} mode, and the tapered section including two end locations,

the end locations of the taper section located at electric field minimum locations of said TE_{10n} mode.

Claim 34 (currently amended): An apparatus for supporting generation of at least one hybrid arc/microwave plasma discharge, the apparatus comprising:

a) a cavity supporting at least one of a TE mode and a TM mode at a microwave frequency; and

b) means for coupling at least one torch module to said cavity,

wherein said cavity has a narrow section, a wide section, and a tapered section arranged between the narrow and wide sections, and wherein ~~The apparatus of claim 29,~~ the narrow section has a length of about $m\lambda_z/2$, where λ_z is the wavelength of said TE_{10n} mode in the axial direction of the cavity, and m is an integer determined by the number of torches to be hosted in said cavity.

Claim 35 (new): The apparatus of claim 1, wherein in the presence of microwave energy, the apparatus generates a plasma torch which exits the cavity, said generated plasma torch having a second energy level, said second energy level being greater than said first energy level.

Claim 36 (new): The apparatus of claim 1, wherein said apparatus is operable without cooling fluid.

Claim 37 (new): The apparatus of claim 1, wherein the apparatus is operable without a vacuum chamber.

Claim 38 (new): The apparatus of claim 1, wherein said arc torch module is powered by an electrical non-microwave source and wherein said arc torch module generates an electrical arc resulting in generated seed plasma used to seed a microwave discharge to produce a high density plasma torch.

Claim 39 (new): The apparatus of claim 1, wherein the cavity is open to atmospheric conditions.

Claim 40 (new): The apparatus of claim 1, wherein a hybrid arc microwave plasma discharge is generated independent of whether or not a pressurized gas flow is present.

Claim 41 (new): The apparatus of claim 1, wherein a hybrid arc microwave plasma discharge is generated independent of whether or not the combination of the microwave source output power level and Q of the cavity supports the generation of plasma from microwave energy without the introduction of seed plasma.

Claim 42 (new): The apparatus of claim 1, wherein a hybrid arc microwave plasma discharge is generated independent of whether or not the microwave source operates at an output energy level sufficient to reach a breakdown threshold and produce plasma without the introduction of seed plasma.

Claim 43 (new): The apparatus of claim 18,

wherein said cavity is a low Q cavity with a value less then 30, and

wherein said microwave source is operated at an output energy level resulting in microwave energy levels within

said cavity being below breakdown threshold in the absence of seed plasma.

Claim 44 (new): The apparatus of claim 1 further comprising:

d) synchronization circuitry to keep arc discharge in synchronization with microwave discharge in each cycle.

Claim 45 (new): The apparatus of claim 26, wherein an implemented combination of the microwave source output power level and cavity Q is insufficient to generate plasma from the microwave energy without an introduction of seed plasma.

Claim 46 (new): The apparatus of claim 1, wherein the apparatus is portable.

Claim 47 (new): The apparatus of claim 1, wherein said microwave source and said arc torch module are directly coupled to said cavity.

Claim 48 (new): The apparatus of claim 1, wherein plasma is produced in an open environment.

Claim 49 (new): The apparatus of claim 1, wherein the plasma is directed in the absence of a confining tube.

Claim 50 (new): The apparatus of claim 1, wherein said apparatus is operable in the absence of a stub tuner or mode conversion device to achieve microwave coupling to a

degree sufficient to produce microwave based plasma discharge.